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EARLY COMMISSIONING OF MEP WORKS FOR BETTER BUILDING PERFORMANCE

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ABSTRACT

Mechanical, Electrical and Plumbing (MEP) systems play a pivotal role in functionality of high-rise building (HRB) projects. Building commissioning helps to ensure that the building systems operate as intended, confirming their compliance with design and owner's requirements. Studies have highlighted the benefits of MEP commissioning from initial stages especially in HRB projects. However, due to a variety of reasons, MEP commissioning is frequently restricted to achieving "practical completion" at the project handover stage, Thus, the maximum benefits of this approach is not experienced due to the absence of commissioning activities in the initial building stages. This study aims to investigate the building commissioning activities for MEP works during the pre-design and design project stages of HRB projects in Sri Lanka. Firstly, the commissioning activities that should be carried out during the stages were identified from the literature. Then, 20 semi-structured interviews were conducted to explore their application in Sri Lankan HRB projects. Findings revealed that most activities were not conducted or conducted in an inadequate manner during the pre-design and design stages. Activities such as appointment of a third-party commissioning authority, establishment of commissioning scope, and preparation of commissioning plan were especially given poor attention. Lack of standards specialised to Sri Lanka, cost and time constraints, and unavailability of technology and experts were found as the major challenges for poor implementation of initial commissioning procedures. The findings provide a useful first step towards enhancing the early implementation of building commissioning procedures for MEP works in the local context.

Keywords: *Building commissioning; High- rise buildings; MEP systems; Sri Lanka.*

1. INTRODUCTION

The Mechanical, Electrical, and Plumbing (MEP) systems function as the lifeblood of the buildings (Khan & Shaari, 2023). These MEP systems consist of plumbing works, Heating, Ventilation, and Air-Conditioning (HVAC), electrical, energy conservation and elevator maintenance and other related installations and comprise complex processes, activities, and resources. Once the operational stage begins, these services are essential for the proper functioning of a building (Han et al., 2022) and for ensuring the expected comfort and safety for occupants. MEP works may constitute up to 40 to 60% of total project costs. Moreover, the rework rate for the MEP installations is also high approaching 20% (Wu et al., 2022). In high rise buildings (HRBs), the percentage of MEP work is around 26% of the total construction work (Riley et al., 2005; Wang & Leite, 2016). Accordingly, Crowe et al. (2020) have highlighted the requirement of a systematic

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approach for involving MEP works in HRBs that consider user requirements and bring more value through business-building alignment.

As described by Crowe et al. (2020), building commissioning is aimed at improving the execution of both new and existing construction endeavours. It attempts to verify the proper installation, testing, and functioning of the building systems according to their intended design (Coyner & Kramer, 2017). In addition, Vejrum (2023) stated that this is a comprehensive approach which centres on confirming and recording that all systems and components authorised are systematically mapped out, conceived, set up, evaluated, and utilized to fulfil the owner's project requirements for a novel structure and substantial refurbishments. Accordingly, commissioning provides remedial actions for minimizing reworks, which has become a significant challenge within the construction industry since they lead to inefficiency and unnecessary resource depletion while impacting both the design and construction stages of projects (Harker, 2018). Thus, commissioning can be identified as a tool that is essential for ensuring project cost, quality, and timeline achievements.

Several studies have highlighted the benefits of MEP commissioning from initial project stages especially in HRB projects. For example, building commissioning during start-up is advantageous for resolving initial issues and ensuring that HRBs operate as intended by bringing systems to full functionality (Caglayan et al., 2022). Furthermore, this proactive approach aims to swiftly address potential design-related issues, minimising the need for later reworks. However, due to time and budget constraints, commissioning is frequently restricted to achieving "practical completion", and the objectives may remain unrealized (Noye et al., 2015). This lack of attention to building commissioning in the early project stages can lead to several drawbacks, such as reworks, incorrect operation, inadequate documentation, missing equipment, and untrained operators, hampering efficiency and long-term functionality (Doloi, 2014). In addition, neglecting commissioning for MEP works from the planning stage can also result in schedule delays, uncontrolled delivery schedules, and increased construction costs, as well as improper fits during installation due to as-built deviations between structures and the MEP layout (Wang et al., 2016). Despite this, still building commissioning is often viewed as an activity or a set of activities to be conducted at project handover. This view is particularly prevalent in the local context as evidenced in the works of authors such as Pilanawithana and Sandanayake (2016) and Samarasinghe et al. (2016). Hence, this study aims to investigate the building commissioning activities for MEP works during the early project stages of HRB projects, which in turn is essential to ensure long-term functionality and efficient building performance. The paper first presents an overview of MEP works in HRBs and the concept of building commissioning. Then, the research methodology is detailed. The findings on the current approach to commissioning in the Sri Lankan context are briefly discussed next. Thereafter, the findings on the application of building commissioning activities during the predesign and design stages and the challenges for implementing the same are discussed. Finally, the conclusions and the implications of the research findings are presented.

2. OVERVIEW OF MEP WORKS IN HIGH-RISE BUILDINGS

MEP systems in HRBs include essential sub-systems such as electrical distribution system, heating, ventilation and air-conditioning (HVAC), potable water supply and distribution, sanitary drainage and sewage systems, fire protection systems and elevators and escalators (Han et al., 2022; Hu et al., 2023). These services are significant for the basic functioning and the quality of life of occupants. For example, MEP services ensure the efficient distribution of power, water, and climate control throughout the building (Jawad et al., 2021). Without the proper functioning of these MEP systems, HRBs would be uninhabitable, impractical, and unsustainable (Monsberger, 2019). Hence, according to Lee and Ahn (2018), MEP systems can be considered as the lifeblood of HRB structures.

3. BUILDING COMMISSIONING

According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE, 2019), building commissioning is a "quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria". Thus, commissioning helps to ensure that building systems operate as intended, confirming their compliance with design and owner's requirements, and documenting the process.

According to Doloi (2014), building commissioning should begin during the concept design phase, where project goals and performance criteria was established and ensure that MEP systems are designed to meet specific standards and expectations. Similarly, Monsberger (2019) highlights that to obtain maximum benefits, commissioning must begin in initial stages such as strategic definition, concept design and technical design where the initial MEP designs are outlined in modern construction projects. Thus, several existing literatures (Coyner & Kramer, 2017; Frye et al., 2002; Su & Thomson, 2016) have categorised building commissioning aspects under four main stages, including pre-design, design, construction, and post-construction. These four main stages can be defined using the work stages of the RIBA Plan of Work 2020 as given in Table 1.

Table 1: Categorisation of commissioning stages in existing literature according to the stages of RIBA plan of work 2020

Commissioning stages in existing literature	Relevant stages of RIBA plan of work 2020
Pre-design stage	Strategic Definition stage
	Preparation and Brief stage
Design stage	Concept Design, and
	Spatial Coordination
	Technical Design stage
Construction stage	Manufacturing and Construction stage
Post-construction stage	Hand over
	In-Use stage

Lack of building commissioning for MEP works in the early design stages can lead to several challenges. Eon et al. (2020) identified the drawbacks including discrepancies between the as-designed and as-built energy performance of the building often due to a lack of knowledge and communication between stakeholders. Inadequate consideration of requirements in the early design stages can also result in energy performance gaps in non-domestic buildings, impacting the overall efficiency and sustainability of the HRBs (Thompson et al., 2022). Thus, this paper particularly focuses on the pre-design and design stage commissioning activities for MEP works particularly in the context of Sri Lankan HRBs.

4. RESEARCH METHODOLOGY

This study aimed to investigate the building commissioning activities for MEP works during the early project stages of HRB projects and the challenges associated with the same. Through the literature survey, the commissioning activities that should be conducted in the pre-design and design stages were identified. The study used a qualitative approach as it allowed to gain a deeper understanding about the applicability of these activities in commissioning MEP systems in Sri Lankan HRB projects and challenges in doing the same. Semi-structured interviews were chosen as the data collection method because they offer the flexibility to gather additional pertinent information during data collection without being limited to a structured questionnaire. Interviews were conducted with twenty (20) experts who were passionate, well experienced and have the knowledge regarding the commissioning for MEP systems in the Sri Lankan context as evidenced by their years of experience in the industry and the number of MEP projects involved (refer to Table 2). An interview guideline was prepared based on the literature review findings to guide the interview process. The interviewees were selected using purposive sampling with the aim of covering all perspectives including client, contactor, and consultants. The interviews lasted between 40-55 minutes each and were conducted either in-person or online, based on the availability of the respondents. The number of interviews conducted was limited to 20 due to data saturation. The profile of the selected interviewees is given in Table 2.

Table 2: Profile of interviewees

Respondent	Designation	Experience in MEP context (Years)	No. of MEP projects involved	Current perspective	Specialized systems
E1	Senior consultant	44	100+	Consultant	HVAC systems
E2	Deputy General Manager - Design	30	30+	Contractor	Mechanical, Plumbing system
E3	MEP Manager - Design, Estimation and Quality Assurance	28	25+	Contractor	Overall MEP
E4	Maintenance Engineer	25	10	Client	Overall MEP
E5	Senior MEP Manager, Consultant	20	15	Client	Overall MEP

Respondent	Designation	Experience in MEP context (Years)	No. of MEP projects involved	Current perspective	Specialized systems
E6	MEP Site Manager	19	46	Contractor	Overall MEP
E7	Site Engineer	10	5	Contractor	Electrical System
E8	Maintenance Engineer	10	3	Client	Overall MEP
E9	Engineer - Design & Estimation	8	15	Contractor	Fire, Electrical and LPG
E10	Site Engineer	8	11	Contractor	HVAC, Plumbing System
E11	Assistant MEP Manager	8	10+	Contractor	Fire system
E12	MEP Site Engineer	8	5	Contractor	Overall MEP
E13	Resident Electrical Engineer	8	5	Consultant	Electrical
E14	Lead Engineer	7	6	Consultant	Overall MEP
E15	Electrical Engineer	6	15+	Contractor	Electrical System
E16	Assistance Electrical Engineer	6	20+	Contractor	Electrical systems
E17	Mechanical Engineer	5	3	Consultant	Mechanical, Plumbing Systems
E18	Senior Project Engineer	5	16	Contractor	Plumbing, Fire System
E19	MEP Engineer	4	2	Contractor	Overall MEP
E20	Assistant Quantity Surveyor	2	3	Contractor	Overall MEP

The collected data were analysed using manual content analysis, and the findings are discussed in the following section.

5. FINDINGS AND DISCUSSION

5.1 CURRENT APPROACH TO COMMISSIONING OF MEP WORKS IN SRI LANKA

Interviewees overwhelmingly highlighted how the commissioning process is conducted as an aspect in the handing over stage in the local context. For instance, 06 out of 20 respondents (i.e. E4, E5, E9, E10, E11 and E12) highlighted that even the preparation for the commissioning activities were conducted around 4 months before project completion. According to E13, the method statements and checklists are also prepared at the last moment and submitted to the consultant for approval.

There appears to be a misconception, particularly among the contractors in the local context, regarding commissioning as a final stage activity. For instance, as E4 highlighted, "*contractors think after commissioning everything is over, so they try to finish it as soon as possible".* Similarly, sub-contractors conduct the system start-up checks only after all the installations are completed. Some of the higher-grade contractors have neglected initial commissioning aspects to reduce the overheads required for hiring MEP engineers. It appears that many of the Sri Lankan HRB projects experience delays in completion due to the poor attention given to commissioning activities.

5.2 BUILDING COMMISSIONING ACTIVITIES CONDUCTED IN PRE-DESIGN STAGE

This stage involves the initial planning of MEP systems (Grondzik, 2009). Commissioning works for MEP systems at this stage aim to verify that the design and installation of these systems align with the project requirements and standards (Su & Thomson, 2016). Identifying potential issues or conflicts with other building components is crucial to ensure the overall performance and functionality of the high-rise building (Grondzik, 2009). Accordingly, altogether, 09 commissioning activities that should be conducted in the pre-design stage were identified from the literature. Table 3 provides the interview findings on the application of these commissioning activities during the pre-design stage in Sri Lankan HRB projects.

Table 3: Application of commissioning activities in pre-design stage in Sri Lanka

Activity No.	Commissioning activity	Not conducted	Conducted inadequately	Conducted with deficiencies	Conducted adequately	Conducted appropriately
1	Defining owners' project requirements	0	1	2	17	0
2	Developing the basis of design	1	3	3	13	0
3	Establishing the commissioning scope	10	7	3	0	0
4	Preparation of a preliminary commissioning plan	15	2	3	0	0
5	Appointment of the commissioning authority	18	0	0	2	0
6	Early discussion and collaboration	2	10	8	0	0
7	Integrating commissioning with the project schedule	0	3	7	10	0
8	Budget estimation	0	0	3	17	0
9	Review of certification requirements	2	0	3	15	0

Findings show that most of the commissioning activities in the pre-design stage are not conducted or conducted in an inadequate manner in the Sri Lankan context.

One of the key commissioning aspects that is not conducted in the pre-design stage is activity no 5, the appointment of third-party commissioning authority. According to E2, this was mainly attributed to cost limitations. Findings revealed that in the Sri Lankan

context, many of the commissioning activities were carried out by the project's consultant and contractor rather than a third party. For instance, E12 highlighted that a chartered engineer performs the final approvals of the systems, such as electrical and fire systems. However, 2 respondents identified the use of a commissioning authorities in foreign funded projects. As per E5, *"there is a practice of appointing a third-party authority in foreign funded projects, this should be specified in the tender as well".* Additionally, E3 mentioned that "*the higher-grade contractors have in-house commissioning teams. Actually, this is not a third party".* In addition, 05 out of the 20 interviewees (i.e. E5, E6, E11, E14, E20) also noted that typically clients tend to appoint a third-party for commissioning towards the middle or final stages of a project, if they feel that the process is not properly conducted. However, in such instances, all or most of the installations are completed, and the party has less knowledge regarding the project.

Secondly, the establishment of commissioning scope is another aspect that is not conducted in the Sri Lankan context, according to the respondents. In the pre-design stages mainly, the focus is on the architectural and aesthetic aspects rather than the commissioning aspects. The interviewees also noted that there were difficulties in identifying client requirements, which resulted in difficulties in preparing a proper scope. According to E10, this often leads to contractors providing outcomes that are totally different to what the client asked. Further, it appears that some projects shifted this activity to other stages. For example, E5 stated that this was sometimes considered in the tender stage due to the involved cost. According to him, "*In my point of view because of the less knowledge regarding the scope preparation, this is not conducted in a proper manner. The testing scope is prepared, but we don't prepare a proper commissioning scope in most projects".*

Findings further highlighted the absence of commissioning plans in most of the local HRB projects. Further, it appears that the few projects that do prepare this plan do so in an inadequate manner. As highlighted by E6, due to absence of proper commissioning scope contractors often prepare this according to their own knowledge and submit to consultants. Furthermore, these plans are not implemented in the sites as well. In addition, there are numerous issues and deficiencies in the planning and preparation. According to E16, *"these plans are prepared based on the knowledge of the people involved and not according to the guidelines. There are no guidelines specialised to the Sri Lankan context, even from CIDA. Documents are incomplete and not comprehensive".* 06 out of 20 (i.e. E3, E7, E12, E16, E18 and E19) interviewees stated that this activity is often shifted to the construction stage, while 03 others (i.e. E5, E10, E13) stated that it is sometimes carried out in the handing over stage.

On the other hand, many respondents identified that defining the owners' project requirements is often conducted adequately in this stage. However, poor knowledge that clients have about their project requirements is often an issue. In such scenarios, consultant has the responsibility to clearly determine these requirements. According to E5, "*because of the alterations made by the client time to time and professionals get affected when performing their job."* These aspects act as barriers when implementing commissioning activities properly in this stage.

Allocating a budget for commissioning activities is usually conducted in the pre-design stage. As per E4 and E2, budget allocation depends on the client and E15 and E18 stated that the allocated amount is not sufficient on most occasions. In the local context, a

percentage of the total work done, or a lump sum amount is allocated for these activities based on the experience of professionals without proper identification of the requirements.

Clients who are looking to obtain sustainable certifications and other standard certifications often focus on the certification requirements during this stage. As noted by E1, "*according to the green building requirements there is a must to properly conduct commissioning".* According to E3, "*commissioning clauses must be included in the report. These are considered a prerequisite for the certification. Assurances about the efficiency of the system could be provided through commissioning".* In addition, many of the respondents focused on the COC and other authority certifications such as electricity and fire here as well. As highlighted by E7, *"inspections done by the authorities thoroughly check the commissioning process of electrical and fire systems during the authorisation procedures".*

In the local context, integrating commissioning with the project schedule is mostly conducted in an adequate manner. As highlighted by 04 out of 20 (E1, E5, E6, E110 interviewees, master plans prepared in the pre-design stage include the time allocation for every system that requires commissioning aspects. According to E14, as a thumb rule schedules are included in commissioning. However, the actual application would often differ from these initial schedules. As identified by E5, *"Most of the time, due to project delays, there is no time remaining for commissioning. In these scenarios, the systems are just checked with only start-up checks and determined whether OK."* Accordingly, it was revealed that most of the commissioning activities were actually conducted in different time frames compared to these initial schedules.

As per the above analysis, it was realised that most of the commissioning activities in the pre-design stage were neglected or conducted in an inadequate manner in the local context.

5.3 BUILDING COMMISSIONING ACTIVITIES CONDUCTED IN THE DESIGN STAGE

According to Dehghani-Sanij (2018), this crucial phase focuses on translating the conceptual design into detailed plans and specifications. Further, this phase involves detailed load calculations for equipment selection, meticulous system layouts coordinated with other disciplines, control system design for optimal performance, and comprehensive commissioning plan preparation (ASHRAE., 2019). This diligent work ensures smooth and efficient commissioning, leading to optimal MEP system operation throughout the lifespan of the building (Singh & Anumba, 2023).

Altogether, 13 commissioning activities that should be conducted in the design stage were identified from the literature. Table 4 provides the application of these activities conducted in the design stage of Sri Lankan HRBs.

Table 5: Application of commissioning activities in design stage in Sri Lanka

Activity No.	Commissioning activity	Not conducted	Conducted inadequate	Conducted with deficiencies	Conducted adequately	Conducted appropriately
1	Detailed design review	0	0	1	9	10
2	Construction documents review	0	0	1	4	15
3	Development of commissioning procedures	10	1	4	5	0
4	Basis of design verification	0	3	10	7	0
5	Development of a commissioning plan	10	4	3	0	3
6	Creation of initial checklists and tests	2	0	3	10	5
7	Planning for system manual and training	1	2	4	13	0
8	Development of commissioning specifications	0	6	6	8	0
9	Energy model review	0	2	3	15	0
10	Building performance simulations	12	3	5	0	0
11	Prepare for construction phase commissioning	0	0	5	5	10
12	Regular commissioning meetings	18	0	0	2	0
13	Alignment with the contractor	10	0	3	7	0
14	Preparation of a preliminary commissioning plan	0	0	0	1	0

According to the respondents, there appears to be an improvement of the application of commissioning activities in the design stage compared to the pre-design stage. As given in Table 4, activities such as detailed design review, construction document review, and preparing for construction phase commissioning are usually practised in an appropriate manner in the local context. However, activities such as development of commissioning procedures, development of a commissioning plan and building performance simulations are highlighted as absent in the design stage. On the other hand, the activities such basis for design verification, planning for system manual and training are conducted in an adequate manner. However, the interviewees noted that even these activities *needed further improvement.* In addition to the activities, identified from literature, 'preparation of a preliminary commissioning plan' was identified by E11 as a commissioning activity that should be conducted in this stage.

Findings revealed a lack of collaboration among professionals regarding commissioning activities. It was found that there were no arrangements for the regular commissioning meetings in the projects. As per 04 out of the 20 respondents (E2, E4, E5 and E10), regular progress meetings are utilised to discuss any requirements of commissioning. This drawback could impact the overall efficiency and coordination of commissioning in the projects.

When considering the building performance simulation activities, 12 respondents identified that this activity is not conducted in the local context. As highlighted by E8, typically AutoCAD or project management tools such as Microsoft Project or Primavera

were used for managing the commissioning requirements rather than any software specialised for commissioning. E13 also stated that in the local context commissioning often relied upon manual calculations and rules of thumb.

The development of commissioning procedures and a commissioning plan was another activity that was neglected in the local context. Findings highlighted that this activity was often delayed to the handover stage.

Involving the contractor for commissioning activities in this design stage was only carried out in the design and build type projects. In the traditional procurement method, involvement of the contractor happens after the design aspects. E7 quoted that, *"as I experienced, in the traditional construction projects, there is no involvement of contractor during design stage"*.

On the other hand, most of the experts illustrate the adequate procedures of planning for system manual and training within the context. Most of the owners stated the training requirements in the tender documents themselves. E10 stated that the planning activities in this stage were performed as a norm in the industry, and E4 highlighted the standardisation of training procedures in this stage. In the design and build projects, contractors ask the employers to appoint operational staff to these procedures even though some clients delay these appointments. In addition, several respondents stated that the planning activities for system manuals are conducted adequately in this stage. According to E18, *"we usually plan to obtain system manuals of each and every system by the manufactures and three copies of the same files are submitted with system manuals in the handing over stage".*

Creation of initial checklists and tests are also usually carried out in an adequate manner in this stage. Some organisations prepare these checklists according to the international standards. However, 04 out of the 20 respondents (i.e. E5, E13, E16, and E17) also noted that these checklists are prepared in the construction stage. E16 also highlighted that, *"checklists are created and submitted later for approvals 3 or 4 months before the commissioning activities in the construction stage".*

Activities such as detailed design review and construction documents review appear to be conducted in an appropriate manner. Specifications should be thoroughly evaluated for commissioning aspects at this stage. In the local context, British standards are followed when reviewing these aspects. E17 highlighted that design parameters such as decibel levels, flow rates, lux levels and pressure rates are considered when reviewing designs. E3 stated that, "*in here the drawings and method statements should be double checked and confirmed. The type of material installation thickness and manufacture characteristics are considered".* As per E1, all the construction drawings should be reviewed with the aim of confirming all the components and arrangements that need to be in commission are included in the designs. Ultimately, these two aspects assist maintain the ability of commissioning throughout the projects.

5.4 CHALLENGES TO IMPLEMENT COMMISSIONING IN THE PRE-DESIGN AND DESIGN STAGES IN SRI LANKAN HRB PROJECTS

Several challenges could be identified as root causes for the absence of initial commissioning activities in the HRB projects. Table 5 provides findings from interviews with regard to the challenges of initial implementation of commissioning aspects.

Table 5: Challenges for implementing commissioning in the pre-design & design stages in the Sri Lankan context

No	Challenge	No of respondents
C1	Complexity of systems	8
C2	Issues in stakeholder coordination	8
C3	Cost and time constraints	20
C4	Limited design information	6
C5	Requirement changes during construction	10
C6	Unavailability of expertise and skills	16
C7	Lack of technology and tools	17
C8	Regulatory and compliance issues	6
C9	Issues in documentation	9
C10	Lack of awareness of the benefits	18
C11	Effect of owner/ client's expectations	3
C12	Unavailability of the specialized standard	10
C13	Lack of third-party commissioning experts	13
C14	Payment issues for the consultants	1

Most of the experts highlighted that the cost and time constraints in the projects as the major challenge affecting the initial implementation of commissioning activities. E5 noted insufficient bidding amounts allocated for commissioning activities, and as per E4, *"Due to the financial constraints, owners do not thoroughly go through the commissioning process"*. Lack of awareness of clients regarding the importance of proper commissioning practices is another common challenge. According to E4, "*professionals often fail to showcase the benefits of commissioning to their clients"*.

According to E3, E4, and E8, the economic crisis has led many experts to migrate, resulting in difficulties in appointing qualified professionals. Further, E4 noted that there is a lack of training and poor uptake of technology with regard to commissioning aspects. In addition, respondents also highlighted the lack of a third-party commissioning authority and the unavailability of commissioning standards specialised to Sri Lanka as challenges for proper commissioning in the local context. According to E11, the industry utilises British standards or standards from a developed country. There is a mix of standards, and sometimes these do not fit with the Sri Lankan project environments.

Overall, the findings revealed a widespread misconception of commissioning as a final step in the construction process rather than an ongoing process. Further, it appears that many of the activities that need to be performed in the early stages are carried out at later stages. According to Crowe et al. (2020), incorporating commissioning in the initial stage of a HRB construction project facilitate to ensure that all MEP systems are designed and built to perform optimally and efficiently. Furthermore, Felter and Gelfo (2022) stated that it promotes better communication and coordination among the project team and helps identify and address potential performance issues early in the project life cycle.

Lack of standards specialised to Sri Lanka, cost and time constraints and unavailability of technology and experts are found as the major challenges for the lack of initial

commissioning of MEP works. As noted by Lohne et al. (2015), limited time and budget often restrict the commissioning process to achieving basic functionality rather than optimising performance. Similarly, Caglayan et al. (2022) has also highlighted the difficulty in finding qualified personnel/service providers as a main challenge associated with commissioning.

6. CONCLUSIONS

The aim of this study was to investigate the building commissioning activities for MEP works during the early project stages of HRB projects and the challenges associated with the same. The study was limited to the pre-design and design stages of the building process. Proper commissioning of MEP works from the initial project stages is essential for ensuring that HRBs operate as intended by bringing systems to full functionality. Such a proactive approach can swiftly address any design-related issues, minimising the need for later reworks. However, this study found that there is a widespread misconception in the local context that commissioning is a sole step conducted in the final stages of a project (often before handing over). Key aspects such as preparation of commission plans, commissioning scopes are not conducted in a proper manner the local context. Lack of standards specialised to Sri Lanka, cost and time constraints and unavailability of technology and experts were found as the major challenges for poor implementation of initial commissioning procedures. The findings shed light on the current deficiencies of building commissioning of MEP works in HRBs. This lays the foundation for developing targeted strategies to improve proper application of commissioning activities from initial project stages, thereby leading to improved building performance. As such, it provides a useful first step towards enhancing the early implementation of building commissioning procedures for MEP works in the local context.

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